The co-benefits of biodiversity conservation programmes on wider ecosystem services

Austin, Z; McVittie, A; McCracken, DI; Moxey, A; Moran, D; White, PCL

Published in:
Ecosystem Services

DOI:
10.1016/j.ecoser.2016.06.002

Print publication: 01/08/2016

Document Version
Publisher's PDF, also known as Version of record

The co-benefits of biodiversity conservation programmes on wider ecosystem services

Zoë Austin[a], Alistair McVittie[b], Davy McCracken[c] Andrew Moxey[d], Dominic Moran[b] and Piran C.L. White[a],

[a] *Environment Department, Wentworth Way, University of York, York, YO10 5NG*

[b] *Scotland's Rural College (SRUC), Land Economy, Environment & Society, King's Buildings, Edinburgh, EH9 3JG*

[c] *Scotland's Rural College (SRUC), Hill & Mountain Research Centre, Crianlarich, FK20 8RU*

[d] *Pareto Consulting, 29 Redford Avenue, Edinburgh, EH13 0BX*

*Corresponding author. Tel: +44 (0) 1904 323118; e-mail: zoe.austin@york.ac.uk.

Abstract

While multiple ecosystem service benefits are increasingly emphasised in policy as an outcome for land management, most conservation management and legislation is currently focused on conserving specific species and habitats. These management interventions may provide multiple co-benefits for other ecosystem services but more information is needed on where these synergies occur in order to realise these benefits. In this paper, we use expert data obtained from structured interviews with key stakeholders to examine the perceived impacts of 11 species-specific conservation schemes on wider ecosystem services in Scotland, UK. With some exceptions, impacts were perceived to be mostly positive or neutral, suggesting that there are many potential opportunities when looking to manage for the delivery of multiple ecosystem services. Unsurprisingly, 'wild species diversity' and 'environmental settings' are the ecosystem services perceived to benefit the most from species conservation management. Despite the clear benefits of aligning biodiversity conservation and ecosystem service objectives, many challenges remain and future policy and associated management will need to tackle issues of scale as well as the distribution of costs and benefits.

Keywords: Agri-environment, Expert data, Habitat management, Interview, Management interventions, Species Action Framework

1. Introduction

Since the release of the Millennium Ecosystem Assessment (MA, 2005) there has been a growing interest in the use of ecosystem services frameworks when looking for policy solutions that aim to maximise ecosystem benefits from our landscapes. In particular, there is policy and practitioner interest in designing management approaches consisting of multiple interventions that can address multiple outcomes (e.g. biodiversity conservation, food security, water quality, natural flood management, climate change mitigation and adaptation), and acknowledge and potentially minimise conflict and trade-offs. This is especially relevant given that both natural and financial resources with which we have to produce these essential ecosystem services are limited (Maskell, 2013).

Despite this interest, if the concept of ecosystem services is to be integrated more fully into land planning and management, there are still many barriers that need to be overcome (de Groot et al. 2010). In particular, there is a need for increased understanding of how we can manage our landscapes to deliver multiple ecosystem benefits given that in the past, the focus has often been to produce large quantities of only a few ecosystem services, mainly timber, fibre, and food. We also need to understand how ecosystem services interact so that trade-offs can be minimised and synergies can be maximised in order to optimise benefits to ecosystems and society (Bennett et al. 2009; Howe et al, 2014). Identifying where these synergies exist in-line with how the land is currently managed for certain ecosystem services is therefore essential for incorporating ecosystem services more widely within existing land management practices.

While multiple ecosystem services are increasingly emphasised in policy as an outcome for land management, most of the conservation management and legislation currently practised is tightly focused on management interventions for conserving specific species and habitats (Maes et al. 2012; Pearson, 2016). Nevertheless, many management interventions intended to benefit the conservation of a particular species or habitat may bring multiple benefits in terms of the diversity of other, wider ecosystem services provided (Bradbury et al. 2010; Rhymer et al. 2010; Fisher et al.

2011; Eastwood et al. 2016), especially if overall levels of biodiversity are enhanced (Rey Benayas et al. 2009; Whittingham, 2011). Indeed, evidence suggests that the relationship between biodiversity ecosystem service provision is often positive, although this relationship can be complex and service dependent (Harrison et al. 2014).

Therefore, the co-benefits of managing for biodiversity may offer many opportunities for synergies between traditional species conservation management and the delivery of a wide range of ecosystem services but we need to understand these relationships much better in order to realise these benefits in terms of optimised management (Mcfadyen, 2012; Whittingham, 2011; Ekroos et al. 2014). We especially need to ask, which interventions can support multiple objectives, which other objectives will continue to require bespoke action, and how this mix of multi-functional and bespoke actions can be planned within a landscape.

In particular, there is a need for data on the type and costs of conservation management actions and the outcomes of the management at a species, habitat and ecosystem service level. But there is currently little empirical evidence on the effectiveness of different interventions in achieving these co-benefits. Monitoring of outcomes is not always implemented, and where it is, it is rarely designed to measure benefits in terms of wider ecosystem service provision (Raffaelli and White 2013). Where empirical data on impacts are lacking, informal knowledge from stakeholders and other experts is being used increasingly in the assessment of management interventions implemented as part of conservation programmes (Cullen 2013). But with some exceptions (Austin et al., 2015; Laycock et al. 2009, 2011, 2013) there are few studies that have used such information as part of a critical assessment of the effectiveness or cost-effectiveness of species-specific conservation programmes, regarding either their original objectives or the potential impacts of the schemes on ecosystem service delivery.

In this paper, we use data obtained from structured interviews with expert stakeholders to examine the perceived impacts of a number of species conservation schemes on wider ecosystem services in

Scotland, UK. We capture the perceived co-benefits of the conservation schemes on a pre-defined list of ecosystem services, assess the strength of the impact, and whether it leads to an increase or decrease in ecosystem service provision. Supplementary qualitative data were collected to examine how and why these impacts are occurring, and how they might arise as a result of any specific management interventions within the conservation programme. We use the quantitative and qualitative data to identify potential synergies between traditional species management and the delivery of wider ecosystem services in order to increase understanding of how we can manage our landscapes to deliver multiple ecosystem benefits. Conservation schemes available within Scotland form the focus of the study, but the approach and interpretation are relevant to the evaluation of other biodiversity conservation programmes where information on ecosystem service co-benefits are limited.

2. Methods

2.1. Identifying target species

The species conservation schemes considered in this paper (Table 1) were undertaken through a number of elements of the Scotland Rural Development Programme (SRDP), which helps to deliver the European Union’s Rural Development Regulation in Scotland, in addition to other historic funding programmes such as the Scottish Natural Heritage’s (SNH) Natural Care programme. Together these programmes contribute to the implementation of the Scottish Biodiversity Strategy, which in is in turn pursuant to overall UK biodiversity commitments. The SRDP under consideration covered the period 2007-2013.

To help deliver the Scottish Biodiversity Strategy, SNH recognised that there was a need to prioritise species management, focusing on those where significant gains to overall biodiversity were expected. As a result, a Species Action Framework (SAF) produced in 2007 set out a strategic approach to species management in Scotland. It also identified a 'Species Action List' of 32 species that were the focus of new, targeted management interventions between 2007 and 2012 (http://www.snh.gov.uk/protecting-scotlands-nature/species-action-framework/).

The species selected for this study were drawn from the SAF and include a mix of native bird, mammal, amphibian, insect, fungi and plant species of conservation interest (black grouse, capercaillie, hen harrier, sea eagle, red squirrel, great crested newt, marsh fritillary butterfly, slender scotch burnet moth, hazel gloves fungus, and water vole). These species were those for which we could identify observable conservation actions and monitoring taking place, which was not the case for all species within the SAF. One of our selected study species (corncrake) was not included in the SAF, but was included in our study due to the scale of conservation action being undertaken, including targeted options within the SRDP. The range of species selected and the diversity of habitats they occupy also provide an opportunity to examine a wide variety of management interventions when considering their perceived impacts on ecosystem services (Table 1).

2.2. Stakeholder interviews

Semi-structured interviews were conducted with expert advisors for each case study species to examine the perceived impacts of these selected species conservation schemes on wider ecosystem services. Key contacts were identified for each species by the project team and included species leads and advisors from public agencies (SNH, Forestry Commission); conservation NGOs (Royal Society for the Protection of Birds, Game and Wildlife Conservation Trust, Butterfly Conservation Scotland); land owner and other stakeholder groups (Scottish Land and Estates, SAC Consulting).

These participants were selected for their expertise on the species concerned and their management and not for their expertise on ecosystem services per se. This study was specifically focussed on the perceived impacts of species conservation programmes and these experts were best placed to comment on this as species lead advisors. However, the ecosystem service approach is increasingly driving policy and strategy, so the interviewees in this study and their organisations (mentioned above) will be extremely familiar with the approach. Finally, the interviews were given information regarding ecosystem services well in advance of the interview and were given time at the start of the interview to ask any questions and raise any queries regarding this approach, as explained below.

A total of 20 interviews were conducted with 16 interviewees between October and December 2012. A total of 18 interviews (involving 15 interviewees) were used further in the data analysis due to incomplete answers. Of the 15 interviewees, three were interviewed regarding two species and the remainder regarding one species each). The resulting number of interviews regarding each species varied from one to four (Table 1). Each interview typically lasted between 1 and 2 hours depending on the number of species under consideration. Interviewees were sent information regarding the interview questions and topic areas prior to the interview, and were asked if they understood all of the ecosystem service categories beforehand. These were explained further by the interviewer if needed.

Face-to-face interviews were conducted where possible, although telephone or video conference interviews were undertaken where necessary. Interviews were recorded with the permission of the participants to support the extensive notes that were taken at the time of interview.

2.3. Assessment of wider ecosystem service co-benefits

The interviewees were first asked a series of questions relating to the type of management interventions that were taking place for the conservation of the species. For each of our selected species there was a range of applicable SRDP interventions either specifically targeting that species, or that provided potentially relevant conservation actions. We identified the funding that was directly related to our study species or linked to the species through published scheme literature. The interviewees were asked to check the list of management interventions for their focal species(s) and to rate their familiarity with those interventions. They were also asked questions relating to relative costs and the effectiveness of the schemes in relation to specific objectives (full details of these results are the subject of a previous paper, Austin et al 2015). The interviewees were then asked to assess the wider effects of species interventions in terms of their impacts on different categories of ecosystem services as classified by the UK National Ecosystem Assessment (Figure 1). In particular, the participants were asked to consider the extent to which the biodiversity conservation programmes (and associated management interventions) linked specifically to the species that they manage, might lead to changes in the provision of these ecosystem services. They were then asked whether, based on their expert judgement, impacts on these ecosystem services might led to slight or large increases in ecosystem service provision (scores of 1 or 2 respectively) or lead to slight or large decreases in ecosystem service provision (scores of -1 or -2 respectively). When participants were asked to give their score, they were also asked to explain the context behind the score that they gave. For example, if a participant thought that management interventions intending to benefit the species black grouse would lead to a decrease in the provision of the ecosystem service category ‘crops, livestock and fish’, they were then asked to explain their answer and include information on any specific impacts, specific management interventions and the scale at which this impact was perceived to be taking place. (A summary of the main questions asked at interview are listed in Supplementary information A).

3. Results

Our results show that across all of the species-related interventions examined in this study, the greatest perceived co-benefits (on average) were associated with the ecosystem service categories of ‘wild species diversity’, ‘environmental settings’ and ‘pollination’ (Figure 2). The lowest perceived co-benefits (on average) were associated with the ecosystem service category ‘water supply’ and there were no perceived co-benefits for the ecosystem service category of ‘noise regulation’ (Figure 2). These ecosystem services were therefore not examined further.

There were positive average impact scores associated with the species-related interventions on 10 ecosystem services overall, but this is subject to differing levels of variability for each ecosystem service (Figure 2). The perceived impact scores differ for each ecosystem service according to focal conservation species and in some cases there are perceived negative impacts associated with species-related interventions for some ecosystem services (Figure 3a-3i).

Specifically, negative impacts were perceived in relation to some conservation management actions for certain species with respect to ‘wild species diversity’ (Figure 3a), ‘trees, standing vegetation and peat’ (Figure 3e), ‘crops, livestock and fish’ (Figure 3f) and ‘disease and pest regulation’ (Figure 3i). Interventions intending to benefit hen harriers have perceived negative impacts across three of these ecosystem service categories. The qualitative data collected enabled us to examine this further (a summary of the qualitative data collected is provided in Supplementary Information B). According to one interviewee, management for hen harriers may have a negative impact on the ‘crops, livestock and fish’ due to the potential de-stocking of livestock to improve moorland habitat for this species.

However, there were also negative perceived impacts on ecosystem service provision as a result of management for other species. According to one interviewee, the management interventions associated with the conservation of great crested newts can result in a loss of natural vegetation which may impact negatively on the ecosystem service of ‘trees, standing vegetation and peat’ at the local scale (Figure 3e). Management interventions associated with black grouse conservation may lead to de-stocking of livestock and may therefore have a small negative impact on this ecosystem service, as can management for sea eagles according to the interviewee(Figure 3f). However, the sea eagle management plan has been introduced by SNH to support livestock farmers if this occurs.

Despite these negative perceived impacts, for many of the species-related interventions, the perceived impacts on ecosystem services are mostly neutral or positive. In particular we found that management interventions intended to benefit three of the bird species (black grouse, capercaillie and corncrake) had mostly positive perceived co-benefits for all ecosystem services (Figures 3a-3i).

This is with the exception of black grouse impacts on livestock as mentioned above. The qualitative data collected were essential in understanding these findings. For example, our interviewees explained that conservation management interventions for black grouse and capercaillie may include planting trees - which may lead to increases in the provision of this ecosystem service which will have knock-on implications for the provision of the ecosystem service of 'environmental settings' (as native forestry increases, more people may visit the area). In addition, the other management interventions associated with this species (such as the creation of species rich grassland) may also lead to increases in other non-target bird species and greater pollination provision. For the corncrake, management interventions such as late mowing and cutting management are likely to have positive co-benefits for wider species diversity (especially butterflies and wildflowers), pollination (as a result of more pollinators) and the ecosystem service category 'environmental settings'.

4. Discussion

Empirical data relating to ecosystem service co-benefits from species conservation management are rarely collected, and we have therefore utilised informal expert knowledge from key stakeholders and managers. We did not seek to quantify the amount of service provision, either in absolute terms for each category or in relative terms across categories. This reflects our need to apply the assessment scheme across a range of species, and that on the whole, the scoring was undertaken by different people for each species (some interviewees considered multiple species). These participants were selected for interview as they were identified as the key advisors for each species and their related conservation schemes. The quantitative and qualitative data that they gave regarding the related impacts on ecosystem services reflect years of experience and expert opinion based on related data regarding each species. Nevertheless, our results are based on stakeholder perceptions (sometimes from one participant for an individual species conservation programme) and not directly from empirically derived data, and this should be considered when interpreting the results.

In this paper, we have found that the perceived co-benefits of some key species-specific conservation interventions are clearly leading to impacts on wider ecosystem services. With some noted exceptions, such co-benefits were positive (or neutral) for many species-specific interventions suggesting that there are many potential areas for synergies when looking to manage for the delivery of multiple ecosystem services. In particular, we found that the current habitat management interventions for the three bird species (black grouse, capercaillie and corncrake) may offer many other positive co-benefits, as supported by previous studies (Wilkinson et al, 2012) Unsurprisingly, ‘wild species diversity’ and ‘environmental settings’ are likely to benefit the most from the current conservation interventions practised for these species. However, there is now a need to understand more about the processes that lead to these co-benefits in order to ensure that potential ecosystem service benefits are achieved.

Since this study was undertaken, the subsequent Scottish Rural Development Programme (2014-2020) has incorporated the potential for any one conservation scheme to provide multiple environmental benefits into the approach http://www.gov.scot/Topics/farmingrural/SRDP). Nevertheless, at the time of writing, the issue of monitoring outcomes still needs to be resolved. Arguably, if adequate ecosystem service indicators can be developed and measured at sufficient temporal and spatial resolution, then we may also be able to indirectly determine the potential effectiveness of conservation schemes.

This study highlights the potential for and direction of impact regarding the co-benefits (or dis-benefits) of species biodiversity conservation on ecosystem service provision. We have seen within our results that managing for biodiversity may not always result in positive impacts for some ecosystem services. For some ecosystem services, evidence suggests that increased levels of biodiversity can lead to increases in the levels of service provision (Harrison et al. 2014). However, in some cases, the diversity needed to provide certain services may be low compared to those required by biodiversity conservation objectives. For example, monocultures or exotic species can be more effective at providing certain ecosystem services when compared to a diverse community of native species (Bullock et al, 2011). While there may be situations where multiple objectives can be achieved simultaneously, future landscape planning policy and practice will need to acknowledge any trade-offs when looking to deliver multiple ecosystem services (Howe at el, 2014).

Many of the perceived ecosystem service impacts associated with biodiversity conservation schemes that were captured in this study are occurring on a local scale and are therefore more difficult to observe at the regional level across which policy operates. This is not to say that impacts from local-scale management interventions are not contributing to ecosystems services at a larger scale, but they may have a greater impact if they were applied at the landscape level rather than on individual sites without taking into account the surrounding management (Mckenzie et al, 2013). This issue of scale creates further challenges when it comes to beneficiaries and who pays for the management interventions. In this study we have examined biodiversity conservation schemes which encourage landowners to manage their land for the benefit of wildlife and the environment. Currently, landowners are only compensated for the management interventions that contribute to local impacts on biodiversity and not for their contribution to wider-scale ecosystem services, but the beneficiaries of those ecosystem services will be the wider community and the public, in addition to local private landowners (Macfadyen et al, 2012). A more comprehensive understanding of the beneficiaries and providers of management interventions, and their distribution in space and time, would help to underpin the development of new strategies that seek to optimise ecosystem services and biodiversity conservation delivery.

Conclusions

It is clear that existing biodiversity conservation schemes targeted at certain species have both positive and, in some cases, negative impacts on wider ecosystem services. We have identified where synergies between biodiversity conservation schemes and their co-benefits for wider ecosystem services are likely to occur, but further empirical data from monitoring studies would be useful to support specific recommendations for integrative management to deliver multiple biodiversity and ecosystem service objectives from landscapes. We have focused on conservation schemes within Scotland to examine these issues, but the approaches used and interpretations drawn could be applied to the assessment of other biodiversity conservation programmes where potential impacts on wider ecosystem services are unknown. A universal consideration is that despite the clear benefits of aligning biodiversity conservation and ecosystem service objectives, many challenges remain. Any future policy and associated mechanisms for optimising both objectives will need to tackle issues of scale as well as the distribution of costs and benefits..

Acknowledgements

This work was funded by the Scottish Government. ZA and PCLW are grateful to the Natural Environment Research Council Biodiversity and Ecosystem Service Sustainability (BESS) programme for additional funding (project code: NE/K001620/1). We would like to thank all of the interview participants who provided their valuable data and time.

References

Austin, Z., McVittee, A., McCracken, D., Moxey, A., Moran, D. & White, P.C.L. (2015) Integrating quantitative and qualitative data in assessing the cost-effectiveness of biodiversity conservation programmes. Biodiversity and Conservation, 24, 1359-1375

Batáry, P., Dicks, L. V. Kleijn, D and Sutherland, W. J. (2015) The role of agri-environment schemes in conservation and environmental management. Conservation Biology, 29, 1006-1016

Bennett, E.M., Peterson, G.D., and Gordon, L.J. (2009) Understanding relationships among multiple ecosystem services. Ecology Letters, 12, 1394-1404

Bradbury, R.B., Stoate, C., Tallowin, J.R.B. (2010) Lowland farmland bird conservation in the context of wider ecosystem service delivery. Journal of Applied Ecology, 47, 986-993

Bullock, J.M., Aronson, J., Newton, A. C., Pywell, R. F., and Rey-Benayas, J.M (2011) Restoration of ecosystem services and biodiversity: conflicts and opportunities. Trends in Ecology and Evolution, 26, 541-549

Cao, Y., Elliott, J., McCracken, D. I., Rowe, K., Whitehead, J and Wilson, L (2009) Estimating the scale of future environmental land management requirements for the UK. Report to the UK Land Use Policy Group (LUPG). ADAS UK Ltd and Scottish Agricultural College

Cullen, R., (2013) Biodiversity protection prioritisation: a 25-year review. Wildlife Research, 40, 108–116

de Groot, R. S. (2010) Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecological Complexity, 7, 260-272.

Eastwood, A., Brooker, R., Irvine, R. J., Artz, R. R. E., Norton, L. R. Bullock, J. M. Ross, L. Fielding, D. Ramsey, S., Roberts, J., Anderson, W., Dugan, S., Cooksley, S., Pakeman, R. J. (2016) Does nature conservation enhance ecosystem services delivery? Ecosystem Services, 17, 152-162.

Ekroos, J., Olsson, O., Rundlof, M., Watzold, F., and Smith, H. G. (2014) Optimizing agri-environment schemes for biodiversity, ecosystem services or both? Biological Conservation, 172, 65-71

Fisher, B. and Turner, R. K. (2008) Ecosystem services: classification for valuation. Biological Conservation, 141, 1167-1169.

Fisher, B., Bradbury, R. B., Andrews, J. E., Ausden, M., Bentham-Green, S., White, S. M and Gill, J. A (2011) Impacts of species-led conservation on ecosystem services of wetlands: understanding co-benefits and tradeoffs. Biodiversity Conservation, 20, 2461–2481.

Harrison, P. A., Berry, P. M., Simpson, G., Haslett, J.R., Blicharska, M., Bucur, M. , Dunford, R., Egoh, B., Garcia-Llorente, M., Geamănă, N., Geertsema, W., Lommelen, E., Meiresonne, L and Turkelboom, F. (2014) Linkages between biodiversity attributes and ecosystem services: A systematic review. Ecosystem Services, 9, 191-203

Howe, C., Suich, H., Vira, B., Mace, G.M. (2014) Creating win-wins from trade-offs? Ecosystem services for human well-being: A meta-analysis of ecosystem service trade-offs and synergies in the real world. Global Environmental Change, 28, 263–27

Laycock, H., Moran, D., Smart, J., Raffaelli, D and White P.C.L. (2009) Evaluating the cost-effectiveness of conservation: the UK Biodiversity Action Plan. Biological Conservation, 142, 3120–3127

Laycock, H., Moran D., Smart, J., Raffaelli, D and White, P.C.L. (2011) Evaluating the effectiveness and efficiency of biodiversity conservation spending. Ecological Economics 70, 1789–1796

Laycock, H., Moran D., Raffaelli, D.G and White P.C.L. (2013) Biological and operational determinants of the effectiveness and efficiency of biodiversity conservation programs. Wildlife Research 40, 142–152

MA (Millennium Ecosystem Assessment). (2005) Ecosystems and human well-being: Current state and trends. Island Press, Washington, DC.

Macfadyen, S., Cunningham, S.A., Costamagna, A.C., and Schellhorn, N.A (2012) Managing ecosystem services and biodiversity conservation in agricultural landscapes: are the solutions the same? Journal of Applied Ecology, 49, 690-694

Maes, J., Paracchini, M.L., Zulian, G., Dunbar, M.B and Alkemade, R. (2012) Synergies and trade-offs between ecosystem service supply, biodiversity and habitat conservation status in Europe. Biological Conservation, 155, 1-12

Maskell, L.C., Crowe, A., Dunbar,M.J., Emmett, B., Henrys, P., Keith, A.M., Smart, S.M (2013) Exploring the ecological constraints to multiple ecosystem service delivery and biodiversity. Journal of Applied Ecology, 50, 561–571

Mckenzie, A. J., Emery, S. B., Franks, J. R. and Whittingham, M. J. (2013) Landscape-scale conservation: collaborative agri-environment schemes could benefit both biodiversity and ecosystem services, but will farmers be willing to participate? Journal of Applied Ecology, 50, 1274-1280

Porter, R., Norman, R., Gilbert, L. (2011) Controlling tick-borne diseases through domestic animal management: a theoretical approach. Theoretical Ecology, 4, 321-339

Raffaelli, D. G. and White, P. C. L. (2013) Ecosystems and their services in a changing world: an ecological perspective. Advances in Ecological Research, 48, 1-70.

Rhymer, C.M., Robinson, R.A., Smart, J and Whittingham, M.J. (2010) Can ecosystem services be integrated with conservation? A case study of breeding waders on grassland. IBIS, 152, 698-172

Rey Benayas, J. M., Newton, A. C., Diaz, A and Bullock, J. M (2009) Enhancement of biodiversity and ecosystem services by ecological restoration: a meta-analysis. Science, 325, 1121–1124

UK National Ecosystem Assessment (2011) The UK National Ecosystem Assessment: Technical Report. UNEP-WCMC, Cambridge.

Whittingham, M. J (2011) The Future of agri-environment schemes: biodiversity gains and ecosystem service delivery? Journal of Applied Ecology, 48, 509-513

Wilkinson, N.I., Wilson, J.D. & Anderson, G.Q.A. (2012) Agri-environment management for corncrake Crex crex delivers higher species richness and abundance across other taxonomic groups. Agriculture, Ecosystems and Environment, 155, 27–34

Table 1. Examples of management interventions undertaken as part of conservation schemes for the selected species (non-exhaustive list). Examples of the habitat where the species occurs are also provided (non-exhaustive list). The number of interviewees who gave information on each species conservation scheme is listed in the final column.

Species	**Examples of species habitat**	**Examples of management interventions**	**Number of interviewees**
Black grouse (*Lyrurus tetrix*)	Mosaics of moorland and heathland, early stages of coniferous plantations, rough grazings and traditionally managed meadows.	Creation and management of species-rich grassland, moorland grazing management, native woodland creation.	4
Capercaillie (*Tetrao urogallus*)	Native pinewoods, with dense ground cover of blaeberry and heather, but will also use commercial conifer plantations and small numbers remain in a few upland oak woods in Tayside.	Native woodland creation, woodland management (restructuring, woodland grazing, livestock removal, reducing deer impact etc), mammal and bird predator control.	3
Hen harrier (*Circus cyaneus*)	Hen harriers breed on moorlands, peatlands and conifer plantations usually below 500m. Grasslands provide valuable foraging habitats. In winter, birds move to open countryside (lowland farmland, marshland, fenland, heathland and river valleys).	Moorland management including de-stocking of sheep, mammal and bird predator control, woodland management (restructuring, woodland grazing, livestock removal, reducing deer impact etc), supplementary food provision.	1

Sea eagle (*Haliaeetus*)	Found in coastal areas and reintroduced to Scotland in 1975. A self-sustaining population has now formed on the west coast of Scotland	Management of coastal areas, wetland, moorland grazing, sustainable management of native woodlands.	2
Corncrake (*Crex crex*)	In Scotland (April – September), corncrakes live in tall vegetation in hayfields and farm grasslands	Grass mowing and cutting management, management of cover for corncrakes, traditional cropping of Machair.	1
Red squirrel (Sciurus vulgaris)	Conifer and broadleaf woodland	Control of grey squirrel for red squirrel conservation, creation and management of woodlands.	2
Great crested newt (*Triturus cristatus*)	Areas of lowland that contain medium sized ponds, rough grassland, scrub and woodland	Create, restore and manage wetland, manage grass margins, scrub and tall herbs.	1
Marsh fritillary butterfly (*Euphydryas aurinia*)	In Scotland, the main habitat is coastal grasslands with temporary colonies in large (>1 ha) woodland clearings and in other grasslands	Management of habitat mosaics, creation and management of species-rich grassland, grazing management of cattle.	1
Slender Scotch burnet moth (*Zygaena loti*)	Species rich grassland areas close to the coast	Management of habitat mosaics, creation and management of species-rich grassland, grazing management of cattle.	1

Hazel gloves fungus (*Hypocreopsis rhododendr*)	Atlantic Hazel woodland	Management of scrub and tall herb communities, sustainable management of native woodlands.	1
Water vole (*Arvicola amphibious*)	Densely vegetated banks of slow flowing rivers, ditches, lakes and marshes where water is present throughout the year	Control of the invasive species mink, management of wetland (create and restore).	1

Figures

Figure 1: Final ecosystem services and ecosystem goods. *Source: UK NEA (2011), adapted from Fisher et al (2008).*

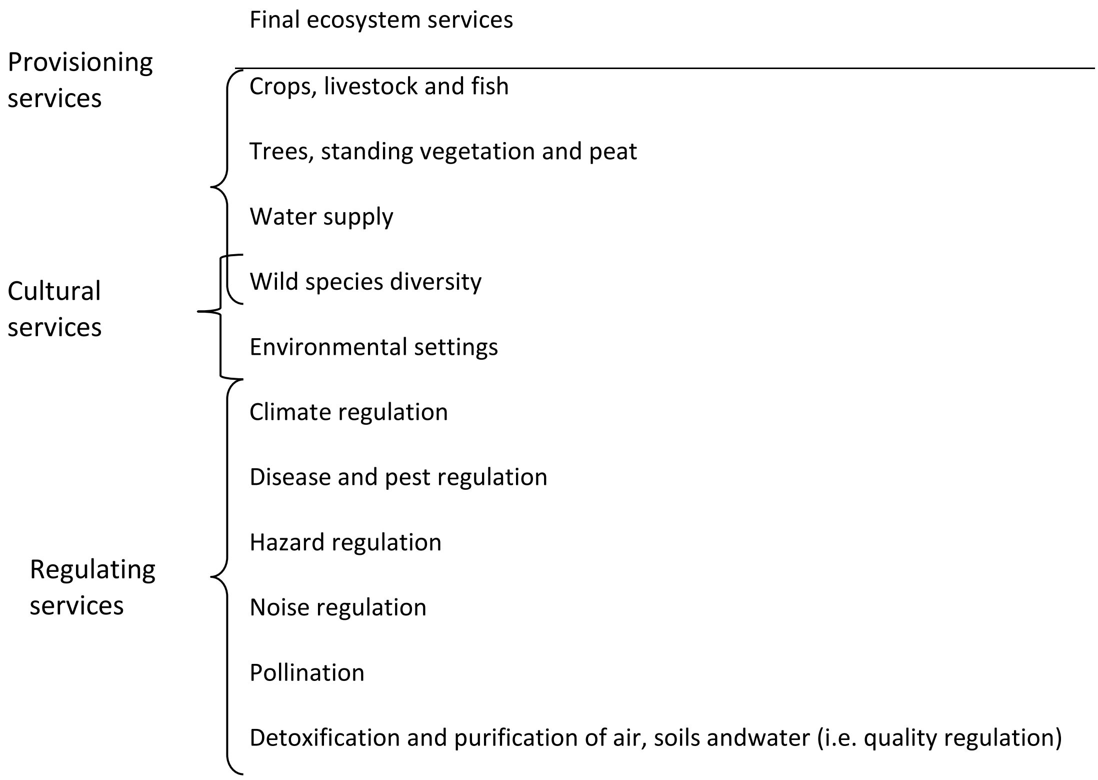


Figure 2. Average perceived impact scores on ecosystem services across all species conservation programmes. An average of all final impact scores for each species relating to each ecosystem services was calculated to show average impacts for each ecosystem service category. Scores for individual species can be positive or negative in relation to impacts on different ecosystem services (see Figure 3). Therefore, all means were positive but some species actions had negative impacts on some ecosystem services. Standard error bars are shown for each ecosystem service category to show variation within the data.

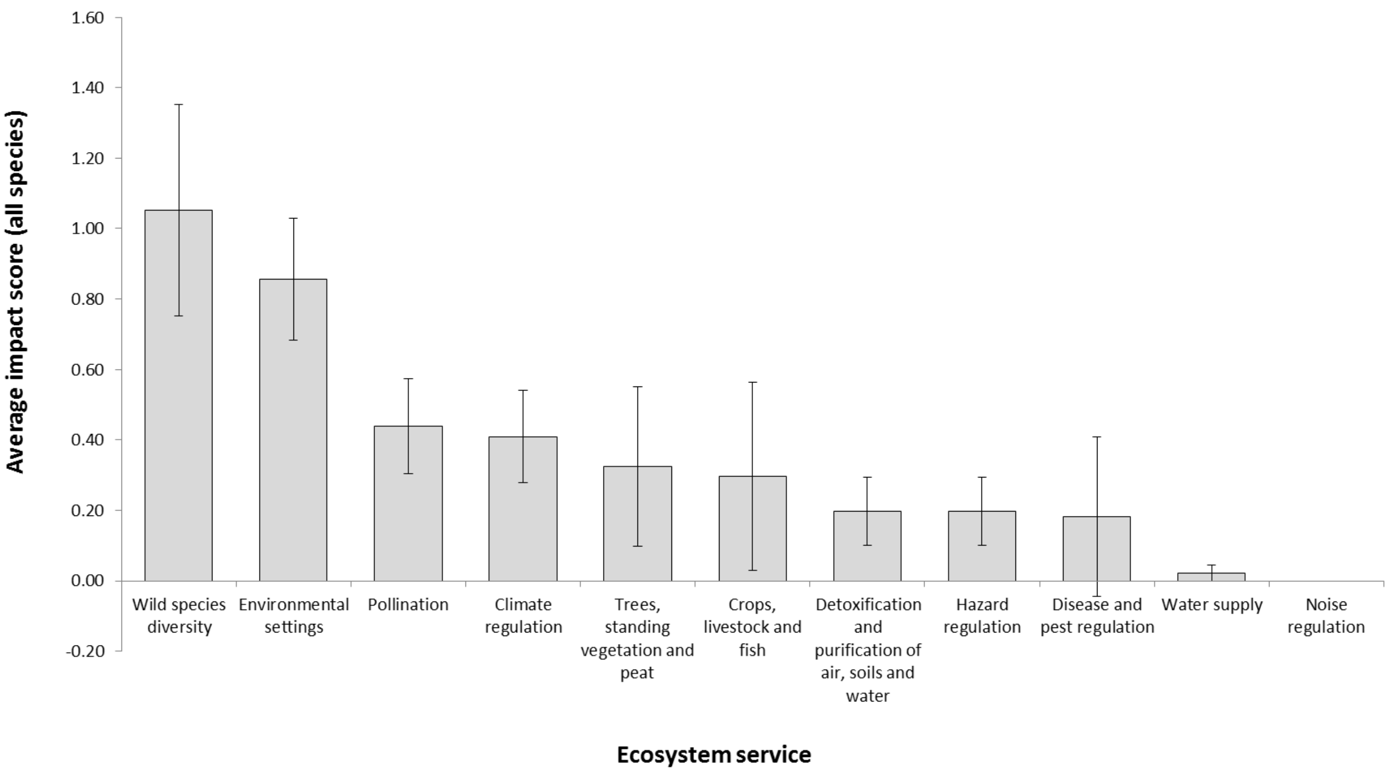
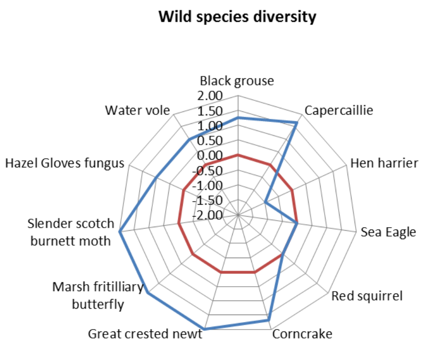
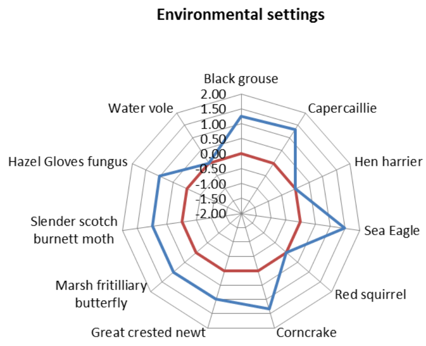


Figure 3. Web diagrams showing perceived impact scores (co-benefits) on ecosystem services for each of the species conservation programmes. Where there was more than one participant commenting on the impacts regarding management aimed at one particular species, an average has been taken. Where there is a no score, or a score of zero, this is taken to mean that there is no 'known' impact on the ecosystem service, according to the participant. The red line on each diagram marks where a score of zero would be and the blue line reflects the average impact scores given regarding each species conservation programme.

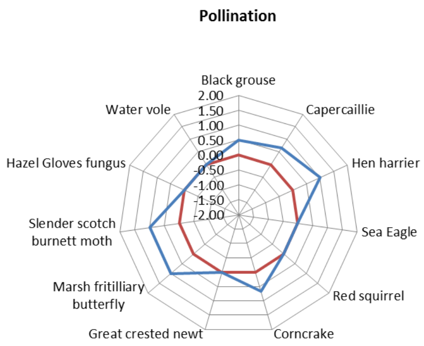
3a.



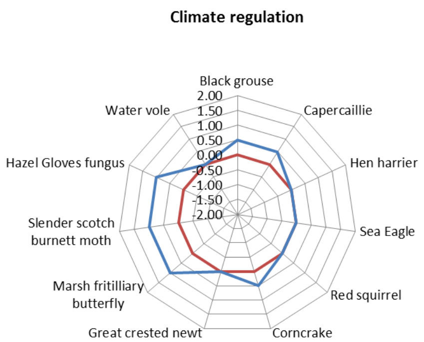
3b.



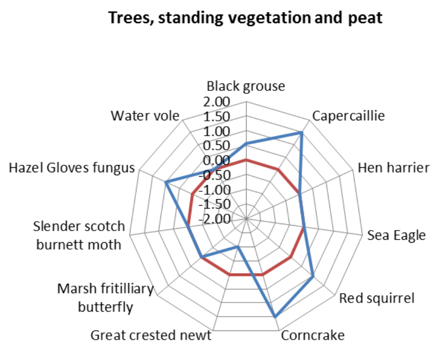
3c.



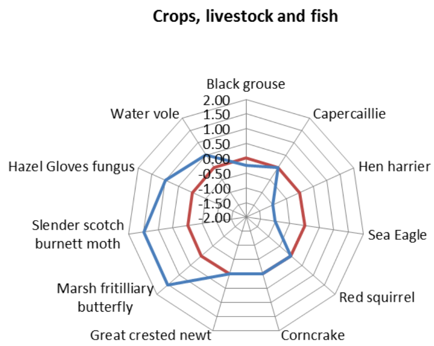
3d.



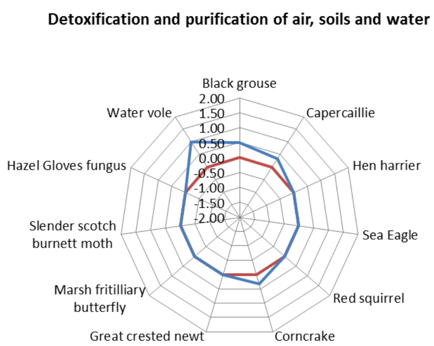
3e.



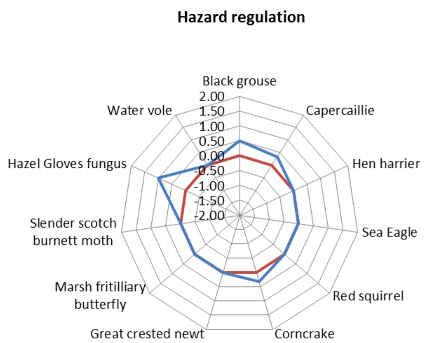
3f.



3g.



3h.



3i.